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**(54) Outermost layers for use in thermographic recording materials**

Aussenschichten für die Verwendung in thermographischen Aufzeichnungsmaterialien

Couches extérieures pour l'utilisation dans des matériaux d'enregistrement thermographiques

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(56) References cited:  
**WO-A-95/12495** **US-A- 4 396 684**

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**EP 0 924 098 B1**

**Description**

## Field of the invention

- 5 **[0001]** The present invention relates to a thermographic recording material comprising a outermost layer suitable for use with thermal heads.

## Background of the invention

- 10 **[0002]** Thermal imaging or thermography is a recording process wherein images are generated by the use of thermal energy. In thermography three approaches are known:

1. Direct thermal formation of a visible image pattern by image-wise heating of a recording material containing matter that by chemical or physical process changes colour or optical density.

- 15 2. Image-wise transfer of an ingredient necessary for the chemical or physical process bringing about changes in colour or optical density to a receptor element.

3. Thermal dye transfer printing wherein a visible image pattern is formed by transfer of a coloured species from an image-wise heated donor element onto a receptor element.

- 20 **[0003]** Direct thermal thermography is concerned with materials which are substantially not photosensitive, but are sensitive to heat or thermosensitive. Image-wise applied heat is sufficient to bring about a visible change in a thermosensitive imaging material. Most of the "direct" thermographic recording materials are of the chemical type. On heating to a certain conversion temperature, an irreversible chemical reaction takes place and a coloured image is produced. This irreversible reaction can be, for example, the reaction of a leucobase with an acid to produce the corresponding dye or the reduction of an organic or inorganic metal compound (e.g. silver, gold, copper or iron compounds) to its corresponding metal thereby producing a visible image. Such imaging materials are described, for example, in US-P 3,080,254, EP-B 614 770, EP-B 614 769, EP-A 685 760, US-P 5,527,757, EP-A 680 833, US-P 5,536,696, EP-B 669 876, EP-A 692 391, US-P 5,527,758, EP-A 692 733, US-P 5,547,914, EP-A 730 196 and EP-A 704 318. A survey of "direct thermal" imaging methods is given e.g. in the book "Imaging Systems" by Kurt I. Jacobson-Ralph E. Jacobson, 30 The Focal Press - London and New York (1976), Chapter VII under the heading "7.1 Thermography".

- [0004]** According to US-P 3,080,254 a typical heat-sensitive copy paper includes in the heat-sensitive layer a thermoplastic binder, e.g. ethyl cellulose, a water-insoluble silver salt, e.g. silver stearate and an appropriate organic reducing agent, of which 4-methoxy-1-hydroxy-dihydronaphthalene is a representative. Localized heating of the sheet in the thermographic reproduction process, or for test purposes by momentary contact with a metal test bar heated to 35 a suitable conversion temperature in the range of about 90-150°C, causes a visible change to occur in the heat-sensitive layer. The initially white or lightly coloured layer is darkened to a brownish appearance at the heated area. In order to obtain a more neutral colour tone a heterocyclic organic toning agent such as phthalazinone is added to the composition of the heat-sensitive layer. Thermosensitive copying paper is used in "front-printing" or "back-printing" using infra-red radiation absorbed and transformed into heat in contacting infra-red light absorbing image areas of an original as 40 illustrated in Figures 1 and 2 of US-P 3,074,809.

- [0005]** EP-B 726 852 discloses a recording material comprising on the same side of a support, called the heat-sensitive side, (1) one or more layers comprising an imaging composition essentially consisting of (i) a substantially light-insensitive organic silver salt being in thermal working relationship with (ii) a reducing agent, and (2) at the same side covering the imaging composition a protective layer, characterized in that the protective layer mainly comprises 45 a cured polymer or cured polymer composition.

**[0006]** WO 94/16905 discloses a thermographic recording film comprising a support carrying: (a) an image-forming system; and (b) a protective layer comprising at least two epoxide moieties in the protective layer topcoat layer and/or in a layer on top of the protective topcoat layer, the ratio of colloidal silica to the compound containing at least two epoxide moieties being at least 2:1 by weight.

- 50 **[0007]** Thermographic recording materials with protective layers according to the teaching of EP-B 726 852 incorporating the imaging composition thereof caused premature failure of thermal heads. O.P. Srivastava suggested at the 3rd Annual Printing Workshop held between 23 and 25 March 1992 in Cambridge, Massachusetts, USA, that sodium and/or potassium ions in thermographic materials form their hydroxides with water present in the atmosphere during thermal printing and that these hydroxides dissolve the outermost glass coating of thermal printing heads and then 55 migrate into the resistor material accelerating heating element failure. Reduction of the sodium and potassium ion concentration to below 601 ppm as disclosed in US 4,396,684 was of itself insufficient to ensure that a protective (outermost) layer, in contact with a thermal head and covering an imaging layer, performed its function of protecting the imaging composition from damage and distortion without causing premature failure of thermal heads and in par-

ticular thin film thermal heads. There is therefore a need for thermographic recording materials with outermost layers, in contact with a thermal head and covering an imaging layer thereof, which perform the function of protecting the imaging composition from damage and distortion without causing premature failure of thermal heads.

[0008] Surprisingly it has been found that thermographic recording materials having outermost layers according to the teaching of EP-B 726 852 with combined sodium and potassium ion concentrations of less than 601 ppm did not necessarily provide protection to the imaging layers thereof. The use in such outermost layers of colloidal silica with free acid groups produced thermographic recording materials which upon image-wise heating with a thermal head became severely distorted and physically damaged. In addition there was an undesirable build-up of material on the thermal head.

Objects of the invention.

[0009] It is therefore an object of the present invention to provide a thermographic recording material with an outermost layer covering an imaging layer thereof, which has sufficient mechanical and thermal stability to protect the imaging composition and does not cause premature failure of thermal heads.

[0010] It is therefore another object of the present invention to provide a production process for a thermographic recording material with an outermost layer covering an imaging layer thereof, which has sufficient mechanical and thermal stability to protect the imaging composition and does not cause premature failure of thermal heads.

[0011] It is therefore a further object of the present invention to provide a method of recording an image by image-wise heating thermographic recording materials with outermost layers in contact with a thermal head without damaging the thermographic recording material or causing premature failure of thermal heads.

[0012] Further objects and advantages of the invention will become apparent from the description hereinafter.

Summary of the invention

[0013] A thermographic recording material is provided by the present invention comprising on the same side of a support, called the heat-sensitive side, a thermosensitive element and a outermost layer which contains a cured polymer or cured polymer composition and colloidal silica, characterized in that the colloidal silica is substantially present in its acidified form and the outermost layer further contains a buffer with a pH between 2 and 7 consisting of at least one acid and at least one non-metallic salt of an acid; a method of recording an image therewith and a production process therefor. In a preferred embodiment of the present invention the thermographic recording material is substantially light-insensitive.

[0014] A method of recording an image is also provided by the present invention comprising the steps of: providing a thermographic recording material as described above, image-wise heating of the thermographic recording material by means of a thermal head contacting the heat-sensitive side of the thermographic recording material and removing the thermographic recording material from the thermal head.

[0015] A process is further provided by the present invention for producing a thermographic recording material including on one side of a support, called the heat-sensitive side, a thermosensitive element, the outermost layer on the heat-sensitive side containing colloidal silica and a cured polymer or cured polymer composition, comprising the steps of: providing the heat-sensitive side of the support with an outermost layer by coating with a composition containing colloidal silica and ingredients which subsequently upon drying and curing produce a cured polymer or cured polymer composition; and drying and curing the outermost layer, characterized in that the colloidal silica is substantially present in its acidified form and the outermost layer further contains a buffer with a pH between 2 and 7 consisting of at least one acid and at least one non-metallic salt of an acid.

[0016] Preferred embodiments of the present invention are disclosed in the detailed description of the invention.

Detailed description of the invention.

Colloidal silica is substantially present in its acidified form

[0017] By the term colloidal silica is meant colloid-size particles of amorphous silica. Colloidal silica is usually used in the form of a silica sol, being an aqueous dispersion of colloidal silica. By the expression "substantially in its acidified form" is meant that neutralizing cations such as alkali ions, ammonium ions etc. are substantially absent. Colloidal silica substantially present in its acidified form with a specific surface area greater than 200 m<sup>2</sup>/g is preferred.

Buffer with a pH between 2 and 7 consisting of at least one acid and at least one non-metallic salt of an acid

[0018] Particularly preferred buffers for use in the thermographic recording materials of the present invention have

a pH between 3 and 5.

**[0019]** Non-metallic salts include ammonium salts, the term ammonium salts including salts with both substituted and unsubstituted ammonium ions. The term substituted ammonium ions includes substitution with alkyl and/or aryl groups and also heterocyclic ring systems with nitrogen atoms for example pyridinium, pyrimidinium and the like.

**[0020]** Preferred buffers with a pH between 2 and 7 consisting of at least one acid and at least one non-metallic salt of an acid consisting of a weak acid and a non-metallic salt are:

phosphate/phosphoric acid buffers and carboxylate/carboxylic acid buffers. Particularly preferred buffers with a pH between 2 and 7 consisting of at least one acid and at least one non-metallic salt of an acid consisting of a weak acid and a non-metallic salt are: ammonium hydrogen phthalate/phthalic acid, ammonium dihydrogen phosphate/phosphoric acid, ammonium dihydrogen phosphate/citric acid, substituted ammonium acetate/acetic acid, ammonium acetate/acetic acid, ammonium succinate/succinic acid, ammonium hydrogen maleate/maleic acid etc. An especially preferred buffer according to the present invention is the ammonium acetate/acetic acid buffer.

**[0021]** Suitable buffers with a pH between 2 and 7 are:

BUF01: 30g ammonium acetate and 150 mL acetic acid diluted to 1L with deionized water with a pH of 3.90;

BUF02: 173.4g acetic acid and 59.3g 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) diluted to 1L with deionized water and DBU added to attain a pH of 3.87;

BUF03: 173.4g acetic acid and 58.2g triethanolamine diluted to 1L with deionized water with a pH of 3.95;

BUF04: 173.4g acetic acid and 50.4g diisopropylethylamine diluted to 1L with deionized water and diisopropylethylamine added to attain a pH of 3.86;

BUF05: 173.4g acetic acid and 39.5g triethylamine diluted to 1L with deionized water with a pH of 3.93;

BUF06: 173.4g acetic acid and 47.3g tris(hydroxymethyl)amino-methane diluted to 1L with deionized water, with a pH of 3.88;

BUF07: 100g ammonium acetate and 77 mL acetic acid diluted to 1L with deionized water with a pH of 4.8;

BUF08: 300g ammonium acetate and 22mL acetic acid diluted to 1L with deionized water with a pH of 5.8.

Outermost layer on the heat-sensitive side of the thermographic recording material

**[0022]** According to the present invention the outermost layer on the heat-sensitive side of the thermographic recording material is produced using a composition containing colloidal silica substantially present in its acidified form, ingredients which subsequently upon drying and curing produce a cured polymer or cured polymer composition and a buffer with a pH between 2 and 7 consisting of at least one acid and at least one non-metallic salt of an acid.

**[0023]** In a preferred embodiment of the present invention the cured polymer or cured polymer composition is the reaction product of hydrophilic polymers having active hydrogen atoms with hardening agents selected from the group consisting of polyisocyanates, aldehydes, titanates, zirconates, sulfone, boric acid and hydrolyzed tetraalkyl orthosilicates. Preferred hardening agents are selected from the group consisting of formaldehyde, glyoxal, glutardialdehyde and hydrolyzed tetramethyl orthosilicate.

**[0024]** Suitable hydrophilic binders for use according to the present invention are: polyvinyl alcohol, copolymers of ethene and polyvinyl alcohol, gelatin, cellulose derivatives e.g. hydroxyethylcellulose, hydroxypropylcellulose etc. with polyvinyl alcohol being particularly preferred.

**[0025]** In general this protects the imaging layer of the thermosensitive element from atmospheric humidity and from surface damage by scratching etc. and prevents direct contact of printheads or heat sources with the imaging layer of the thermosensitive element. Outermost layers for thermosensitive elements which come into contact with and have to be transported past a heat source under pressure, have to exhibit resistance to local deformation and good slipping characteristics during transport past the heat source during heating.

**[0026]** The outermost layer, may further comprise a dissolved lubricating material and/or particulate material, e.g. talc particles, optionally protruding from the outermost layer. Examples of suitable lubricating materials are a surface active agent, a liquid lubricant, a solid lubricant or mixtures thereof, with or without a polymeric binder. The surface active agents may be any agents known in the art such as carboxylates, sulfonates, phosphates, aliphatic amine salts, aliphatic quaternary ammonium salts, polyoxyethylene alkyl ethers, polyethylene glycol fatty acid esters, fluoroalkyl C<sub>2</sub>-C<sub>20</sub> aliphatic acids. Examples of liquid lubricants include silicone oils, synthetic oils, saturated hydrocarbons and glycols. Examples of solid lubricants include various higher alcohols such as stearyl alcohol, fatty acids and fatty acid esters. Suitable lubricants for the outermost layer compositions are described, for example, in EP-A 138 483, EP-A 227 090, US-P 4,567,113, US-P 4,572,860, US-P 4,717,711, EP-A 311 841, US 5,587,350, US 5,536,696, US 5,547,914, WO 95/12495, EP-A 775 592 and EP-A 775 595.

## Thermosensitive element

**[0027]** According to the present invention, a thermographic recording material is provided comprising a thermosensitive element. Examples of suitable thermosensitive elements are: a leucobase with an acid in a binder, the corresponding dye being produced upon heating, and organic or inorganic metal compounds (e.g. silver, gold, copper or iron compounds) and a reducing agent therefor in a binder, the organic or inorganic metal compound being reduced to its corresponding metal upon heating. Preferred metal organic compounds for use with a reducing agent are organic silver salts.

**[0028]** The thermosensitive element may comprise a layer system in which the ingredients may be dispersed in different layers one of which is an image-forming layer, with the proviso that the active ingredients are in a thermal working relationship with one another i.e. during the thermal development process one active ingredient e.g. the reducing agent in the case of organic heavy metal salt/reducing agent systems, must be present in such a way that it is able to diffuse to the other active ingredient e.g. the substantially light-insensitive organic heavy metal salt particles in the case of organic heavy metal salt/reducing agent systems, so that the colour-forming process can take place. The thermosensitive element may be coated onto a support in sheet- or web-form from an organic solvent or from an aqueous medium.

## Organic silver salts

**[0029]** Preferred substantially light-insensitive organic silver salts for use in the thermographic recording materials, according to the present invention, are silver salts of aliphatic carboxylic acids known as fatty acids, wherein the aliphatic carbon chain has preferably at least 12 C-atoms, e.g. silver laurate, silver palmitate, silver stearate, silver hydroxystearate, silver oleate and silver behenate, which silver salts are also called "silver soaps". Silver salts of modified aliphatic carboxylic acids with thioether group as described e.g. in GB-P 1,111,492 and other organic silver salts as described in GB-P 1,439,478, e.g. silver benzoate, may likewise be used to produce a thermally developable silver image. Combinations of different organic silver salts may also be used in the thermographic recording materials of the present invention.

**[0030]** A preferred process for producing a suspension of particles containing a substantially light-insensitive organic silver salt is disclosed in EP-A 754 969.

## Organic reducing agents

**[0031]** Suitable organic reducing agents for the reduction of the substantially light-insensitive organic silver salts are organic compounds containing at least one active hydrogen atom linked to O, N or C, such as is the case with, aromatic di- and tri-hydroxy compounds; aminophenols; METOL™; p-phenylenediamines; alkoxy-naphthols, e.g. 4-methoxy-1-naphthol described in US-P 3,094,41; pyrazolidin-3-one type reducing agents, e.g. PHENIDONE™; pyrazolin-5-ones; indan-1,3-dione derivatives; hydroxytetrone acids; hydroxytetrone imides; hydroxylamine derivatives such as for example described in US-P 4,082,901; hydrazine derivatives; and reductones e.g. ascorbic acid; see also US-P 3,074,809, 3,080,254, 3,094,417 and 3,887,378.

**[0032]** Among the catechol-type reducing agents, i.e. reducing agents containing at least one benzene nucleus with two hydroxy groups (-OH) in ortho-position, the following are preferred: catechol, 3-(3,4-dihydroxyphenyl) propionic acid, 1,2-dihydroxybenzoic acid, gallic acid and esters e.g. methyl gallate, ethyl gallate, propyl gallate, tannic acid, and 3,4-dihydroxy-benzoic acid esters. Particularly preferred catechol-type reducing agents, described in EP-A 692 733, are benzene compounds in which the benzene nucleus is substituted by no more than two hydroxy groups which are present in 3,4-position on the nucleus and have in the 1-position of the nucleus a substituent linked to the nucleus by means of a carbonyl group.

**[0033]** The silver image density depends on the coverage of the above defined reducing agent(s) and organic silver salt(s) and has to be preferably such that, on heating above 100 °C, an optical density of at least 2.5 can be obtained. Preferably at least 0.10 moles of reducing agent per mole of organic silver salt is used.

## Auxiliary reducing agents

**[0034]** The reducing agents used in accordance with the present invention being considered as primary or main reducing agents may be used in conjunction with so-called auxiliary reducing agents. Such auxiliary reducing agents are e.g. hydroquinone or catechol substituted with strongly electron-withdrawing groups such as sulfonic acid groups; sterically hindered phenols, such as described in US-P 4,001,026; bisphenols, e.g. of the type described in US-P 3,547,648; sulfonamidophenols, such as described in Research Disclosure, February 1979, item 17842, in US-P 4,360,581 and 4,782,004, and in EP-A 423 891; hydrazides such as disclosed in EP-A 762 196, sulfonyl hydrazide

reducing agents such as disclosed in US-P 5,464,738; trityl hydrazides and formyl-phenyl-hydrazides such as disclosed in US-P 5,496,695; trityl hydrazides and formyl-phenyl-hydrazides with diverse auxiliary reducing agents such as disclosed in US-P 5,545,505, US-P 5,545,507 and US-P 5,558,983; acrylonitrile compounds as disclosed in US-P 5,545,515 and US-P 5,635,339; 2-substituted malondialdehyde compounds such as disclosed in US-P 5,654,130; and organic reducing metal salts, e.g. stannous stearate described in US-P 3,460,946 and 3,547,648. The auxiliary reducing agents may be present in the imaging layer or in a polymeric binder layer in thermal working relationship thereto.

[0035] In a preferred embodiment of the present invention the thermographic recording material comprises a support and a thermosensitive element which further contains a catechol compound substituted with a strongly electron-withdrawing group.

#### Binders for the thermosensitive element

[0036] The thermosensitive element of the thermographic recording materials of the present invention may be coated onto a support in sheet- or web-form from an organic solvent containing the binder dissolved therein or may be applied from an aqueous medium using water-soluble or water-dispersible binders.

[0037] Suitable binders for coating from an organic solvent are all kinds of natural, modified natural or synthetic resins or mixtures of such resins, wherein the organic heavy metal salt can be dispersed homogeneously: e.g. cellulose derivatives, cellulose esters, carboxymethylcellulose, starch ethers, galactomannan, polyurethanes, polycarbonates, polyesters, polymers derived from  $\alpha,\beta$ -ethylenically unsaturated compounds such as after-chlorinated polyvinyl chloride, partially hydrolyzed polyvinyl acetate, polyvinyl alcohol, polyvinyl acetals, preferably polyvinyl butyral, and homopolymers and copolymers produced using monomers selected from the group consisting of: vinyl chloride, vinylidene chloride, vinyl esters, acrylonitrile, acrylamides, methacrylamides, methacrylates, acrylates, methacrylic acid, acrylic acid, vinyl esters, styrenes, dienes and alkenes; or mixtures thereof.

[0038] Suitable water-soluble film-forming binders are: polyvinyl alcohol, polyacrylamide, polymethacrylamide, polyacrylic acid, polymethacrylic acid, polyethyleneglycol, polyvinylpyrrolidone, proteinaceous binders such as gelatine modified gelatines such as phthaloyl gelatine, polysaccharides, such as starch, gum arabic and dextran and water-soluble cellulose derivatives.

[0039] Suitable water-dispersible binders are any water-insoluble polymer e.g. water-insoluble cellulose derivatives, polyurethanes, polycarbonates, polyesters and polymers derived from  $\alpha,\beta$ -ethylenically unsaturated compounds such as after-chlorinated polyvinyl chloride, partially hydrolyzed polyvinyl acetate, polyvinyl alcohol, polyvinyl acetals, preferably polyvinyl butyral, and homopolymers and copolymers produced using monomers selected from the group consisting of: vinyl chloride, vinylidene chloride, acrylonitrile, acrylamides, methacrylamides, methacrylates, acrylates, methacrylic acid, acrylic acid, vinyl esters, styrenes, dienes and alkenes; or mixtures thereof. It should be noted that there is no clear cut transition between a polymer dispersion and a polymer solution in the case of very small polymer particles resulting in the smallest particles of the polymer being dissolved and those slightly larger being in dispersion.

[0040] Preferred water-dispersible binders for use according to the present invention are water-dispersible film-forming polymers with covalently bonded ionic groups selected from the group consisting of sulfonate, sulfinate, carboxylate, phosphate, quaternary ammonium, tertiary sulfonium and quaternary phosphonium groups. Further preferred water-dispersible binders for use according to the present invention are water-dispersible film-forming polymers with covalently bonded moieties with one or more acid groups.

[0041] Water-dispersible binders with crosslinkable groups, e.g. epoxy groups, aceto-acetoxy groups and crosslinkable double bonds are also preferred.

[0042] The binder to organic silver salt weight ratio is preferably in the range of 0.2 to 6, and the thickness of the recording layer is preferably in the range of 1 to 50  $\mu\text{m}$ .

#### Thermal solvents

[0043] The above mentioned binders or mixtures thereof may be used in conjunction with waxes or "heat solvents" also called "thermal solvents" or "thermosolvents" improving the reaction speed of the redox-reaction at elevated temperature. By the term "heat solvent" in this invention is meant a non-hydrolyzable organic material which is in a solid state in the recording layer at temperatures below 50°C, but becomes a plasticizer for the recording layer where thermally heated and/or a liquid solvent for at least one of the redox-reactants.

#### Toning agents

[0044] In order to obtain a neutral black image tone in the higher densities and neutral grey in the lower densities, thermographic recording materials according to the present invention may contain one or more toning agents. The toning agents should be in thermal working relationship with the substantially light-insensitive organic silver salt and

reducing agents during thermal processing. Any known toning agent from thermography or photothermography may be used.

**[0045]** Suitable toning agents are the phthalimides and phthalazinones within the scope of the general formulae described in US-P 4,082,901 and the toning agents described in US-P 3,074,809, US-P 3,446,648 and US-P 3,844,797. Particularly useful toning agents are the heterocyclic toner compounds of the benzoxazine dione or naphthoxazine dione type described in GB-P 1,439,478, US-P 3,951,660 and US-P 5,599,647.

Polycarboxylic acids and anhydrides thereof

**[0046]** According to a preferred embodiment of the thermographic recording material of the present invention, the thermosensitive element further contains at least one polycarboxylic acid and/or anhydride thereof in a molar percentage of at least 20 with respect to the substantially light-insensitive organic silver salt and in thermal working relationship therewith. The polycarboxylic acid may be aliphatic (saturated as well as unsaturated aliphatic and also cycloaliphatic) as disclosed in US-P 5,527,758 or an aromatic polycarboxylic acid, may be substituted and may be used in anhydride form or partially esterified on the condition that at least two free carboxylic acids remain or are available in the heat recording step.

Stabilizers and antifoggants

**[0047]** In order to obtain improved shelf-life and reduced fogging, stabilizers and antifoggants may be incorporated into the thermographic recording materials of the present invention. Examples of suitable stabilizers and antifoggants and their precursors, which can be used alone or in combination, include the thiazolium salts described in US-P 2,131,038 and 2,694,716; the azaindenes described in US-P 2,886,437 and 2,444,605; the urazoles described in US-P 3,287,135; the sulfoxatechols described in US-P 3,235,652; the oximes described in GB-P 623,448; the thiuronium salts described in US-P 3,220,839; the palladium, platinum and gold salts described in US-P 2,566,263 and 2,597,915; the tetrazolylthio-compounds described in US-P 3,700,457 for example 1-(3'-n-nonylamido-oxophenyl)-1H-tetrazole-5-thiol; the mesoionic 1,2,4-triazolium-3-thiolate stabilizer precursors described in US-P 4,404,390 and 4,351,896; the tribromomethyl ketone compounds described in EP-A 600 587; the combination of isocyanate and halogenated compounds described in EP-A 600 588; the vinyl sulfone and  $\beta$ -halo sulfone compounds described in EP-A 600 589; and those compounds mentioned in this context in Chapter 9 of "Imaging Processes and Materials, Neblette's 8th edition", by D. Kloosterboer, edited by J. Sturge, V. Walworth and A. Shepp, page 279, Van Nostrand (1989); in Research Disclosure 17029 published in June 1978; and in the references cited in all these documents.

Surfactants and dispersants

**[0048]** Surfactants and dispersants aid the dispersion of ingredients which are insoluble in the particular dispersion medium. The thermographic recording materials of the present invention may contain one or more surfactants, which may be anionic, non-ionic or cationic surfactants and/or one or more dispersants.

**[0049]** Suitable dispersants are natural polymeric substances, synthetic polymeric substances and finely divided powders, for example finely divided non-metallic inorganic powders such as silica. Suitable hydrophilic natural or synthetic polymeric substances contain one or more hydroxyl, carboxyl or phosphate groups, e.g. protein-type binders such as gelatin, casein, collagen, albumin and modified gelatin; modified cellulose; starch; modified starch; modified sugars; modified dextrans etc. Examples of suitable hydrophilic synthetic polymeric substances are polyacetals, such as polyvinylbutyral; polyvinylalcohol; polyvinylpyrrolidone; polyacrylic acid; and polymethacrylic acid and their copolymers and salts thereof.

Other ingredients

**[0050]** In addition to the above-mentioned ingredients the thermographic recording material may contain other additives such as free fatty acids, antistatic agents, e.g. non-ionic antistatic agents including a fluorocarbon group as e.g. in  $F_3C(CF_2)_6CONH(CH_2CH_2O)_H$ , silicone oil, e.g. BAYSILONET<sup>TM</sup> ÒI A (BAYER AG, GERMANY), ultraviolet light absorbing compounds, white light reflecting and/or ultraviolet radiation reflecting pigments, silica, and/or optical brightening agents.

Support

**[0051]** The support for the thermographic recording material according to the present invention may be transparent, translucent or opaque and is preferably a thin flexible carrier made e.g. from paper, polyethylene coated paper or

transparent resin film, e.g. made of a cellulose ester, e.g. cellulose triacetate, polypropylene, polycarbonate or polyester, e.g. polyethylene terephthalate. The support may be in sheet, ribbon or web form and subbed if needs be to improve the adherence to the thereon coated heat-sensitive recording layer. The support may be made of an opacified resin composition, e.g. polyethylene terephthalate opacified by means of pigments and/or micro-voids, and/or may be coated with an opaque pigment-binder layer, and may be called synthetic paper, or paperlike film. Information about such supports can be found in EP's 194 106 and 234 563 and US-P's 3,944,699, 4,187,113, 4,780,402 and 5,059,579.

#### Coating techniques

**[0052]** The coating of any layer of the thermographic recording materials of the present invention may proceed by any coating technique e.g. such as described in Modern Coating and Drying Technology, edited by Edward D. Cohen and Edgar B. Gutoff, (1992) VCH Publishers Inc. 220 East 23rd Street, Suite 909 New York, NY 10010, U.S.A. Coating may proceed from aqueous or solvent media with overcoating of dried, partially dried or undried layers.

#### Thermographic printing

**[0053]** Thermographic imaging is carried out by the image-wise application of heat either in analogue fashion by direct exposure through an image of by reflection from an image, or in digital fashion pixel by pixel either by using an infra-red heat source, for example with a Nd-YAG laser or other infra-red laser, or by direct thermal imaging with a thermal head.

**[0054]** In thermal printing image signals are converted into electric pulses and then through a driver circuit selectively transferred to a thermal printhead. The thermal printhead consists of microscopic heat resistor elements, which convert the electrical energy into heat via Joule effect. The electric pulses thus converted into thermal signals manifest themselves as heat transferred to the surface of the thermal paper wherein the chemical reaction resulting in colour development takes place. Such thermal printing heads may be used in contact or close proximity with the recording layer. The operating temperature of common thermal printheads is in the range of 300 to 400°C and the heating time per picture element (pixel) may be less than 1.0ms, the pressure contact of the thermal printhead with the recording material being e.g. 200-500g/cm<sup>2</sup> to ensure a good transfer of heat.

**[0055]** The image signals for modulating the laser beam or current in the micro-resistors of a thermal printhead are obtained directly e.g. from opto-electronic scanning devices or from an intermediary storage means, e.g. magnetic disc or tape or optical disc storage medium, optionally linked to a digital image work station wherein the image information can be processed to satisfy particular needs.

**[0056]** Activation of the heating elements can be power-modulated or pulse-length modulated at constant power. The image-wise heating can be carried out such that heating elements not required to produce an image pixel generate an amount of heat ( $H_e$ ) in accordance with the following formula:

$$0.5 H_D < H_e < H_D$$

wherein  $H_D$  represents the minimum amount of heat required to cause visible image formation in the thermographic material. EP-A 654 355 describes a method for making an image by image-wise heating by means of a thermal head having energizable heating elements, wherein the activation of the heating elements is executed duty cycled pulsewise. When used in thermographic recording operating with thermal printheads the thermographic recording materials are not suitable for reproducing images with fairly large number of grey levels as is required for continuous tone reproduction. EP-A 622 217 discloses a method for making an image using a direct thermal imaging element producing improvements in continuous tone reproduction.

**[0057]** Image-wise heating of the thermographic recording material can also be carried out using an electrically resistive ribbon incorporated into the material. Image- or pattern-wise heating of the thermographic recording material may also proceed by means of pixel-wise modulated ultra-sound, using e.g. an ultrasonic pixel printer as described e.g. in US-P 4,908,631.

#### Industrial application

**[0058]** Thermographic recording materials according to the present invention may be used for both the production of transparencies, for example in the medical diagnostic field in which black-imaged transparencies are widely used in inspection techniques operating with a light box, and reflection type prints, for example in the hard copy field. For such applications the support will be transparent or opaque, i.e. having a white light reflecting aspect. Should a transparent base be used, the base may be colourless or coloured, e.g. with a blue colour for medical diagnostic applications.



[0059] The following INVENTION EXAMPLES and COMPARATIVE EXAMPLES illustrate the present invention. The percentages and ratios used in the examples are by weight unless otherwise indicated.

# EXAMPLES

[0060] The following ingredients were used in the thermosensitive element of the examples in addition to those mentioned above:

AgBeh = silver behenate; .  
 B79 = Butvar™ B79, a polyvinyl butyral from MONSANTO;  
 R01 = ethyl 3,4-dihydroxybenzoate;  
 S01 = adipic acid;  
 S02 = tetrachlorophthalic anhydride  
 S03 = benzotriazole  
 T01 = benzo[e][1,3]oxazine-2,4-dione;  
 T02 = 7-(ethylcarbonato)benzo[e][1,3]oxazine-2,4-dione;  
 Baysilon™ MA = a silicone oil, from BAYER AG;

and the following ingredients were used in the outermost layer thereof:

\* Polyviol™ WX 48 20 = a polyvinylalcohol, from Wacker Chemie;  
 \* purified polyvinyl alcohol = Polyviol™ WX 48 20 purified by extraction with methanol/water (75/25 by volume);  
 \* dispersant 01 = Ultravon™ W, a dispersion agent from Ciba Geigy, converted into acid form by passing through an ion exchange column;  
 \* Syloid™ 72 = a porous silica, from Grace;  
 \* Steamic™ OOS = a talc, from Talc de Luzenac;  
 \* type P3 = an Indian talc from Nippon Talc;  
 \* VPAZ 100 = Servoxyl™ VPAZ 100, a mixture of monolauryl and dilauryl phosphate, from Servo Delden B.V.;  
 \* VPDZ 3/100 = Servoxyl™ VPDZ 3/100, a mono[isotridecyl polyglycoether (3 EO)] phosphate, from Servo Delden B.V.;  
 \* Rilanit™ GMS = a glycerine monotallow acid ester, from Henkel AG;  
 \* Levasil™ VP AC 4055 = a 15% aqueous dispersion of colloidal silica with acid groups predominantly neutralized with sodium ions and a specific surface area of 500 m<sup>2</sup>/g, from Bayer AG;  
 \* TMOS = tetramethylorthosilicate hydrolyzed in the presence of methanesulfonic acid.

## INVENTION EXAMPLE 1

Preparation of colloidal silica substantially in its acidic form

[0061] Colloidal silica with free acid groups was prepared from Levasil™ VP AC 4055 by adding 5L of the acidic ion exchange resin LEWATIT™ S100MB to 20L of Levasil™ VP AC 4055, stirring the resulting dispersion for 2 hours, filtering off the spent ion exchange resin and then repeating the process with 5L of fresh LEWATIT™ S100MB. This process reduced the concentration of sodium ions in the 15% aqueous dispersion of colloidal silica from ca. 3000 ppm to ca. 150 ppm.

## COMPARATIVE EXAMPLE 1

Thermosensitive element

[0062] A subbed polyethylene terephthalate support having a thickness of 175µm was doctor blade-coated with a coating composition containing 2-butanone as a solvent and the following ingredients so as to obtain thereon, after drying for 1 hour at 50°C, a layer containing:

\* AgBeh: 4.91g/m<sup>2</sup>  
 \* Butvar™ B79: 19.62g/m<sup>2</sup>  
 \* Baysilon™ MA 0.045g/m<sup>2</sup>  
 \* T01, a toning agent: 0.268g/m<sup>2</sup>

- \* T02, a toning agent: 0.138g/m<sup>2</sup>
- \* R01, a reducing agent: 0.92g/m<sup>2</sup>
- \* S01: 0.352g/m<sup>2</sup>
- \* S02: 0.157g/m<sup>2</sup>
- \* S03: 0.130g/m<sup>2</sup>

Coating of the thermosensitive element with a outermost layer

[0063] An aqueous dispersion was then prepared with the composition given below:

- \* Polyviol™ WX 48 20: 2.5%
- \* dispersant 01: 0.09%
- \* type P3, a talc from Nippon Talc: 0.05%
- \* Syloid™ 72: 0.10%
- \* Servoxy™ VPDZ 3/100: 0.09%
- \* Servoxy™ VPAZ 100: 0.09%
- \* Rilanit™ GMS : 0.18%
- \* TMOS: 2.1%
- \* Levasil™ VP AC 4055, a colloidal silica with acid groups predominantly neutralized with sodium ions: 1.2%

[0064] Those ingredients which were insoluble in water, were dispersed in a ball mill with, if necessary, the aid of a dispersion agent. Before coating the pH of the composition was adjusted to a pH of 3.8 by adding 1N nitric acid. The thermosensitive element was coated with this dispersion to a wet layer thickness of 85µm and the layer dried at 40°C for 15 minutes and then hardened at 45°C for 7 days.

Printing

[0065] Printing was carried out with a printer in which a thin film thermal printing head had been installed. Sheets of the above-mentioned substantially non-photosensitive thermographic recording material were fed at a speed of 4mm/s onto a drum past the thermal printing head mounted in such a way as to contact the substantially non-photosensitive thermographic recording material. The thermal printing head was operated at a line time of 19ms (the line time being the time needed for printing one line), during which it received constant power, and at an average printing power, being the total amount of electrical energy used for printing one line divided by the line time and the surface area of the heat-generating resistors, of 1.25 mJ/dot, being sufficient to obtain maximum density in the recording material.

[0066] A defective heating element, corresponding in position to a pinhole in the outermost layer of the thermal printing head was detected in the prints as a white line after 50 prints.

COMPARATIVE EXAMPLE 2 and INVENTION EXAMPLES 2 to 5

[0067] The thermosensitive elements of COMPARATIVE EXAMPLE 2 and INVENTION EXAMPLES 2 to 5 were produced as described for COMPARATIVE EXAMPLE 1.

[0068] The outermost layers of COMPARATIVE EXAMPLE 2 and INVENTION EXAMPLES 2 to 5 coated onto the thermosensitive element were as described for COMPARATIVE EXAMPLE 1 except that: the talc used was Steamic™ OOS from Talc de Luzenac instead of type P3 from Nippon Talc, purified polyvinyl alcohol was used instead of Polyviol™ WX 48 20, Levasil™ VP AC 4055 was replaced by colloidal silica with free acid groups prepared as described in INVENTION EXAMPLE 1, in the case of INVENTION EXAMPLES 2 to 4 different concentrations of the buffer BUF01 were used as given in table 1 below and in INVENTION EXAMPLE 5 ammonium acetate was added which under the acidic conditions pertaining during the coating process is converted in situ into an ammonium acetate/acetic acid buffer. The compositions of the coating dispersions are given in table 1 below.

Table 1:

Example	Comparative nr 2	Invention nr 2	Invention nr 3	Invention nr 4	Invention nr 5
dispersant 01	0.09%	0.09%	0.09%	0.09%	0.09%
BUF01	0%	0.75%	1.5%	5%	0%
ammonium acetate	0%	0%	0%	0%	sufficient added to obtain pH of 3.8

Table 1: (continued)

Example	Comparative nr 2	Invention nr 2	Invention nr 3	Invention nr 4	Invention nr 5
purified polyvinyl alcohol	2.5%	2.5%	2.5%	2.5%	2.5%
VPDZ 3/100	0.09%	0.09%	0.09%	0.09%	0.09%
VPAZ 100	0.09%	0.09%	0.09%	0.09%	0.09%
Syloid™72	0.11%	0.11%	0.11%	0.11%	0.11%
Steamic™OOS	0.055%	0.055%	0.055%	0.055%	0.055%
Rilanit™ GMS	0.18%	0.18%	0.18%	0.18%	0.18%
acidic colloidal SiO <sub>2</sub> *	1.2%	1.2%	1.2%	1.2%	1.2%
TMOS	2.1%	2.1%	2.1%	2.1%	2.1%

\* produced according to Invention Example nr 1

[0069] Furthermore, the dried thermographic recording materials were hardened at 49°C for 7 days in a relative humidity of 20%.

#### Thermographic printing

[0070] The printer was equipped with a thin film thermal head with a resolution of 300 dpi and was operated with a line time of 19ms (the line time being the time needed for printing one line). During this line time the print head received constant power. Sheets of the thermographic recording materials of COMPARATIVE EXAMPLE 2 and INVENTION EXAMPLES 2 to 5 were fed at a speed of 4mm/s onto a drum past the thermal printing head mounted in such a way as to contact the substantially non-photosensitive thermographic recording material. The average printing power, being the total amount of electrical input energy during one line time divided by the line time and by the surface area of the heat-generating resistors, was 1.6 mJ/dot was sufficient to obtain maximum optical density in each of the thermographic recording materials of COMPARATIVE EXAMPLE 2 and INVENTION EXAMPLES 2 to 5. The linear pressure between the thermal head and the thermographic recording material during printing was 300g wt./cm.

[0071] The damage sustained by the outermost layers of COMPARATIVE EXAMPLE 2 and INVENTION EXAMPLES 2 to 5 in the printer during printing was evaluated using a numerical score between 0 and 5:

- a score of 5 = complete removal of the outermost layer
- a score of 4 = considerable damage to the outermost layer
- a score of 3 = moderate damage to the outermost layer
- a score of 2 = slight damage to the outermost layer
- a score of 1 = very slight damage to the outermost layer
- a score of 0 = no damage to the outermost layer

is given in table 2 below.

Table 2:

Example number	concentration of BUF01	additional ammonium acetate	Surface damage score
Comparative Example 2	0%	no	5
Invention Example 2	0.75%	no	3
Invention Example 3	2.5%	no	3
Invention Example 4	5%	no	0
Invention Example 5	0%	yes to pH = 3.8	3

[0072] From table 2 it can be seen that the outermost layer of the thermographic recording material of COMPARATIVE EXAMPLE 2 with colloidal silica with free acid groups but no buffer that the outermost layer is completely removed

upon thermographic printing and the thermosensitive underneath damaged. The addition of concentrations of BUF01 of 0.75 or 2.5% or the addition of ammonium acetate to obtain a pH of 3.8 resulted in only moderate damage to the outermost layer during thermographic printing and the addition of a concentration of BUF01 of 5% was sufficient to avoid completely damage to the outermost layer.

## Claims

1. A thermographic recording material comprising on the same side of a support, called the heat-sensitive side, a thermosensitive element and a outermost layer which contains a cured polymer or cured polymer composition and colloidal silica, **characterized in that** said colloidal silica is substantially present in its acidified form and said outermost layer further contains a buffer with a pH between 2 and 7 consisting of at least one acid and at least one non-metallic salt of an acid.
2. Thermographic recording material according to claim 1, wherein said buffer has a pH between 3 and 5.
3. Thermographic recording material according to claim 1 or 2, wherein said buffer is an ammonium acetate/acetic acid buffer.
4. Thermographic recording material according to any of the preceding claims, wherein said cured polymer or cured polymer composition is the reaction product of hydrophilic polymers having active hydrogen atoms with hardening agents selected from the group consisting of polyisocyanates, aldehydes, titanates, zirconates, sulfones, boric acid and hydrolyzed tetraalkyl orthosilicates.
5. Thermographic recording material according to any of the preceding claims, wherein said thermosensitive element contains a substantially light-insensitive organic silver salt in thermally working relationship with an organic reducing agent.
6. Thermographic recording material according to any of the preceding claims, wherein said thermographic recording material is substantially light-insensitive.
7. A method of recording an image comprising the steps of: providing a thermographic recording material according to any of the preceding claims, image-wise heating of said thermographic recording material by means of a thermal head contacting said heat-sensitive side of said thermographic recording material and removing said thermographic recording material from said thermal head.
8. Method of recording an image according to claim 7, wherein said thermal head is a thin film thermal head.
9. A process for producing a thermographic recording material including on one side of a support, called the heat-sensitive side, a thermosensitive element, the outermost layer on the heat-sensitive side containing colloidal silica and a cured polymer or cured polymer composition, comprising the steps of: providing the heat-sensitive side of the support with an outermost layer by coating with a composition containing colloidal silica and ingredients which subsequently upon drying and curing produce a cured polymer or cured polymer composition; and drying and curing the outermost layer, **characterized in that** said colloidal silica is substantially present in its acidified form and said outermost layer further contains a buffer with a pH between 2 and 7 consisting of at least one acid and at least one non-metallic salt of an acid.
10. Production process according to claim 9, wherein said buffer with a pH between 3 and 5.

## Patentansprüche

1. Ein thermografisches Aufzeichnungsmaterial, das an der gleichen Seite eines Trägers, als wärmeempfindliche Seite bezeichnet, mit einem wärmeempfindlichen Element und einer Außenschicht, die ein gehärtetes Polymer oder eine gehärtete Polymerzusammensetzung und kolloidale Kieselsäure enthält, überzogen ist, **dadurch gekennzeichnet, daß** die kolloidale Kieselsäure im wesentlichen in ihrer angesäuerten Form enthalten ist und die Außenschicht weiterhin einen Puffer mit einem pH zwischen 2 und 7 enthält, der aus zumindest einer Säure und zumindest einem nicht-metallischen Salz einer Säure besteht.

2. Ein thermografisches Aufzeichnungsmaterial nach Anspruch 1, **dadurch gekennzeichnet, daß** der Puffer einen pH zwischen 3 und 5 aufweist.
3. Ein thermografisches Aufzeichnungsmaterial nach Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** der Puffer ein Puffer aus Ammoniumacetat und Essigsäure ist.
4. Ein thermografisches Aufzeichnungsmaterial nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** das gehärtete Polymer oder die gehärtete Polymerzusammensetzung das Reaktionsprodukt von hydrophilen Polymeren mit aktiven Wasserstoffatomen mit Härtern aus der Gruppe bestehend aus Polyisocyanaten, Aldehyden, Titanaten, Zirconaten, Sulfonen, Borsäure und hydrolysierten Tetraalkylorthosilikaten ist.
5. Ein thermografisches Aufzeichnungsmaterial nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** das wärmeempfindliche Element ein wesentlich lichtunempfindliches organisches Silbersalz in thermischer wirksamer Beziehung zu einem organischen Reduktionsmittel enthält.
6. Ein thermografisches Aufzeichnungsmaterial nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** das thermografische Aufzeichnungsmaterial wesentlich lichtunempfindlich ist.
7. Ein durch die nachstehenden Schritte gekennzeichnetes Bildaufzeichnungsverfahren: Bereitstellen eines thermografischen Aufzeichnungsmaterials nach einem der vorstehenden Ansprüche, bildmäßige Erhitzung des thermografischen Aufzeichnungsmaterials mittels eines in Kontakt mit der wärmeempfindlichen Seite des thermografischen Aufzeichnungsmaterials stehenden Thermokopfes und Entfernung des thermografischen Aufzeichnungsmaterials vom Thermokopf.
8. Bildaufzeichnungsverfahren nach Anspruch 7, **dadurch gekennzeichnet, daß** der Thermokopf ein Dünnschichtthermokopf ist.
9. Ein durch die nachstehenden Schritte gekennzeichnetes Verfahren zur Herstellung eines thermografischen Aufzeichnungsmaterials, das an einer Seite eines Trägers, als wärmeempfindliche Seite bezeichnet, ein wärmeempfindliches Element enthält, wobei die Außenschicht an der wärmeempfindlichen Seite kolloidale Kieselsäure und ein gehärtetes Polymer oder eine gehärtete Polymerzusammensetzung enthält: Überziehen der wärmeempfindlichen Seite des Trägers mit einer Außenschicht und zwar durch Auftrag einer Zusammensetzung, die kolloidale Kieselsäure und Ingredienzien enthält, die anschließend bei Trocknung und Härtung ein gehärtetes Polymer oder eine gehärtete Polymerzusammensetzung ergeben, und Trocknung und Härtung der Außenschicht, **dadurch gekennzeichnet, daß** die kolloidale Kieselsäure im wesentlichen in ihrer angesäuerten Form enthalten ist und die Außenschicht weiterhin einen Puffer mit einem pH zwischen 2 und 7 enthält, der aus zumindest einer Säure und zumindest einem nicht-metallischen Salz einer Säure besteht.
10. Herstellungsverfahren nach Anspruch 9, **dadurch gekennzeichnet, daß** der Puffer einen pH zwischen 3 und 5 aufweist.

#### Revendications

1. Un matériau d'enregistrement thermographique comprenant sur la même face du support, appelée face thermosensible, un élément thermosensible et une couche extérieure qui contient un polymère durci ou une composition polymère durcie et de la silice colloïdale, **caractérisé en ce que** la silice colloïdale est essentiellement présente sous sa forme acidifiée et que la couche extérieure contient en plus un tampon avec un pH entre 2 et 7 constitué par au moins un acide et au moins un sel non métallique d'un acide.
2. Matériau d'enregistrement thermographique selon la revendication 1, **caractérisé en ce que** ledit tampon a un pH entre 3 et 5.
3. Matériau d'enregistrement thermographique selon la revendication 1 ou 2, **caractérisé en ce que** ledit tampon est un tampon d'acétate d'ammonium/acide acétique.
4. Matériau d'enregistrement thermographique selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit polymère durci ou ladite composition polymère durcie est le produit réactionnel de polymères

hydrophiles possédant des atomes d'hydrogène actifs avec des durcissants choisis dans le groupe constitué par des polyisocyanates, des aldéhydes, des titanates, des zirconates, des sulfones, de l'acide borique et des ortho-silicates de tétraalkyle hydrolysés.

5. Matériau d'enregistrement thermographique selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit élément thermosensible contient un sel d'argent organique essentiellement insensible à la lumière qui se trouve en relation thermique opérante avec un réducteur organique.
6. Matériau d'enregistrement thermographique selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit matériau d'enregistrement thermographique est essentiellement insensible à la lumière.
7. Une méthode pour enregistrer une image, comprenant les phases consistant à: fournir un matériau d'enregistrement thermographique selon l'une quelconque des revendications précédentes, chauffer sous forme d'image ledit matériau d'enregistrement thermographique au moyen d'une tête thermique qui entre en contact avec ladite face thermosensible dudit matériau d'enregistrement thermographique et enlever ledit matériau d'enregistrement thermographique de la tête thermique.
8. Méthode pour enregistrer une image selon la revendication 7, **caractérisé en ce que** ladite tête thermique est une tête thermique à couche mince.
9. Un procédé pour produire un matériau d'enregistrement thermographique comprenant sur une face du support, appelée face thermosensible, un élément thermosensible, la couche extérieure sur la face thermosensible contenant de la silice colloïdale et un polymère durci ou une composition polymère durcie, lequel procédé comprend les phases consistant à: munir la face thermosensible du support d'une couche extérieure en appliquant une composition contenant de la silice colloïdale et des ingrédients qui après être séchés et durcis produisent un polymère durci ou une composition polymère durcie; et sécher et durcir la couche extérieure, **caractérisé en ce que** ladite silice colloïdale est essentiellement présente sous sa forme acidifiée et que ladite couche extérieure contient en plus un tampon avec un pH entre 2 et 7 constitué par au moins un acide et au moins un sel non métallique d'un acide.
10. Procédé de production selon la revendication 9, **caractérisé en ce que** ledit tampon a un pH entre 3 et 5.